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Assessment of eco-chemical state of Chiatura municipality natural waters for echo-economic

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Abstract---Hydrochemical and microbiological characteristics of Kvirila River water and spring waters of territories adjacent to Chiatura municipality manganese processing enterprizes have been considered in the work. Kvirila River water and spring waters contaminated with different ingredients have been identified: Kvirila River water belongs to the category of medium-salt (average mineralization) waters; manganese concentration equals to 2.56 mg/l, which comprises 25.6 MPC (maximum permissible concentration). This is stipulated by the fact that Kvirila River below the enterprise is polluted with waste waters resulting from extracted ore washing, which are dumped into Kvirila River; total Mn content in suspended particles and bottom sediments is very high compared to the background level; spring water belong to the category of medium-salt and highly mineralized waters; among polluting ingredients nitrites and sulfates are distinguished by

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their high content; manganese content is within the norm; no contamination according to microbiological parameters is registered.

Keywords---Kvirila River, spring waters, hydrochemistry, manganese, pollution.

Introduction

Chiatura municipality is one of the most vulnerable places of Georgia in terms of environmental conditions, and its major problem is activation of natural phenomena (landslides, mudflows, floods, winds, erosions etc.) against the climate change background, which is facilitated by intensification of mining activity (manganese production) in the municipality. Ore extraction is associated with many controversial issues. On one hand, it is a source of income and creation of new workplaces, but on the other, it does substantial damage to the environment and local population [1,2]. All this may cause forest felling and vegetation cover destruction at large areas, significant degradation of landscape that has a considerable negative effect on biodiversity; eco-systems and food products contamination, soil degradation, great material damage etc. are expectable [3].

Industrial waste waters originated in the ore washing process, contain large quantities of suspended particles, heavy metals, manganese compounds and without any treatment flows into Kvirila River. In addition, approximately 805 845 tons of agglomerates, which contain in average 15.4% of manganese are stored at the dump site located at the left embankment of Kvirila River. Under influence of precipitations this agglomerate flows into Kvirila River and causes its additional pollution [4].

Manganese extraction is accompanied by manganese oxide discharge into atmosphere in the dust form. Winds and precipitations promote its propagation and deposition at the territory of the Municipality [5].

Manganese is an important element for humans and animals. Almost every human organ contains at least small concentrations of manganese. It participates in human and animal blood-formation functions, bone growth process, protein, carbohydrate and fat metabolism etc. In plants, manganese participates in the photosynthesis process [6].

Both manganese deficit and its overplus may lead to negative effect. Manganese doesn't cause acute poisoning. It has cumulative action and is characterized by diverse manifestations when influencing the organism for a long time. It causes the following occupational diseases: manganism, bronchial asthma, allergic dermatitis etc. [7].

Materials and Methods

Physical-chemical and hydrochemical characteristic of Kvirila River waters at the territories adjacent to Chiatura Municipality manganese processing enterprises has been given in the work. It is necessary to establish the purity of Kvirila River waters, as far as Kvirila River water is used for extracted ore washing, after which waste waters are dumped into the river and contaminate it.

Spring water and Kvirila River water samples, as well as suspended particles and bottom sediments have been taken in background points and below the pollution source for solution of problems raised.

The following indicators have been determined in the water samples taken: physical-chemical and microbiological parameters, in particular: pH, electric conductivity; biogenic substances:NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}, principal ions, mineralization, heavy metals: Cu, Zn, Pb, Cd, Ni, Co and general manganese form [8], and microbiological parameters: E-coli, total Coliforms, fecal streptococci [9].

Analyses have been conducted using up-to-date methods and equipment, which meet the requirements and comply with European standards, in particular:

1. Ion-chromatograph-IC-1000; ISO100304-1:2007
2. Spectrophotometric method - SPECORD 205; ISO 7150-1: 2010;
2. Plasma-emission spectrometer - ICP-OES; Epa method 200.8;
4. Field portable apparatus - Hanna Combo pH/EC/TDS/PPM Tester HI98129;
5. IDEX-apparatus
5. pH-meter - Milwaukee-Mi 150.

Results and Discussion

Physical-chemical and hydrological data of Kvirila River are given in Table 1.

As is seen from Table 1, pH value deviation towards alkaline direction is observed in Kvirila River below "Andro" LTD and "Jruchula" LTD, and it comprises 8.1-8.2, compared to the background one (7.7). It should be noted the fact that a content of almost every ingredient in Kvirila River below "Andro" LTD is higher compared to that of "Jruchula" LTD and the more so in comparison with the background one, but only sulfate content exceeds 1.1-times MPC value. There is a large sum of hydrocarbonates, sodium and potassium, as well as calcium and magnesium quantities. Kvirila water mineralization in the proximity of the mentioned enterprise is high and comprises 1159.32 mg/l, while Kvirila River water mineralization in the background point is 227.20 mg/l and it is a medium-salt one (average mineralization) [10]. There is a hazardous situation regarding manganese content. Manganese concentration equals to 2.5649 mg/l, that comprises 25.6 MPCs. This is caused by the fact that Kvirila River below the enterprise is polluted with waste waters resulting from extracted ore washing, which are dumped into Kvirila River.

Among the spring waters a second spring is distinguished by high content of polluting ingredients. Content of nitrites and sulfates surpasses MPC 1.3 and 2.0-times, respectively. Mineralization equals to 1156,40 mg/l, so this water belongs to the category of highly mineralized waters. At that, nitrite content in the first spring 3.8 times exceeds MPC in the first spring. Manganese content in both springs is within the norm.

Except for manganese, no one of identified heavy metals has been found in a quantity exceeding MPC, and no contamination according to microbiological parameters has been registered in spring waters.

Table 1. Physical-chemical and hydrological data of Kvirila River water and spring waters
May, 2024

	Ingredients	**Kvirila – below "Andro" LTD**	**Kvirila – below "Jruchula" LTD**	**Kvirila – background level**	**Spring water 1**	**Spring water 2**	**MPC***	**MPC ****
1	pH	8.1	8.2	7.7	8.2	7.8	6-9	6.5-8.5
2	Electric conductivity, μsms/cm	1100	330	230	450	1170		
3	BOD_5, mg/l	3.14	1.62	1.21	3.12	3.24	6.0	6.0
4	Hardness, mg.eq./l	6.24	3.41	2.24	4.90	9.12	7-10	
5	Ammonia, mgN/l	0.185	0.199	0.218	0.169	0.193	0.39	0.39
6	Nitrites, mg/l	0.059	0.027	0.061	0.761	0.259	0.2	3.3

7	Nitrates, mg/l	1.641	1.254	1.621	11.55	13.31	50	45
8	Phosphates, mg/l	0.268	0.165	0.141	0.281	0.386	3.5	3.5
9	Sulfates, mg/l	536.38	26.70	19.01	76.58	510.85	250	500
10	Chlorides, mg/l	8.57	7.20	3.22	9.27	14.38	250	350
11	Bromine, mg/l	0.052	0.016	0.022	0.028	0.109		
12	Fluorine, mg/l	0.278	0.129	0.036	0.115	0.377	0.7	
13	Hydrocarbonates, mg/l	265.96	212.28	148.84	241.56	283.04		
14	Potassium, mg/l	238.68	20.93	17.28	17.25	169.43		
15	Sodium, mg/l							
16	Calcium, mg/l	82.21	43.48	27.09	53.83	137.01		
17	Magnesium, mg/l	26.07	15.05	10.86	26.91	27.86		
18	Mineralization, mg/l	1159.32	327.20	227.32	441.13	1156.40	1000-1500	
19	E-Coli, per 1 dm^3				not/det	not/det	not allowed	
20	Total Coliforms per 1 dm^3				not/det	not/det		
21	Fecal streptococci per 1 dm^3				not/det	not/det		
22	Manganese, mg/l	2.5649	0.1136	0.0150	0.0154	0.0030	0.4	0.1
23	Copper, mg/l	0.0134	0.0024	0.0040	0.0028	0.0008	2.0	1.0
24	Zinc, mg/l	0.0054	0.0035	0.0012	0.0031	0.0009	3.0	1.0
25	Lead, mg/l	0.0023	0.0011	0.0008	0.0021	0.0015	0.01	0.05
26	Cadmium, mg/l	0.0002	0.0001	0.0001	<0.0001	<0.0001	0.003	0.001
27	Nickel, mg/l	0.0005	0.0023	0.0007	0.0010	0.0005	0.07	0.1
28	Cobalt, mg/l	0.0004	0.0007	0.0003	0.0012	0.0009		0.1

* MPC – maximum permissible concentration according to drinkable water technical regulations (Decree №58 of the Georgian Government as of 15th of January 2014, Tbilisi)

** MPC – maximum permissible concentration according to surface water technical regulations (Decree №425 of the Georgian Government as of 31st of December 2013, Tbilisi)

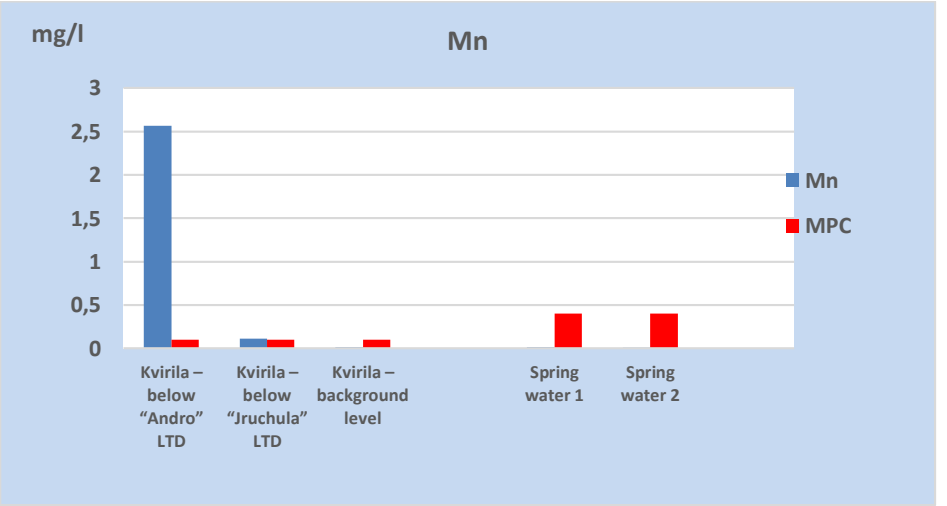

Fig. 1. Manganese content in Kvirila River and spring waters, May, 2024

Table 2. Mn content in Kvirila water suspended solids and bottom sediments
May, 2024

N	Sampling point	Coordinates	Results	
	Suspended solids		**g/kg**	**%**
1	Kvirila – below "Andro" Ltd	X-363027 Y-4686103	58.3	5.83
2	Kvirila – below "Jruchula" Ltd	X-363791 Y-4686878	23.6	2.36
	Sediments			
1	Kvirila – below "Andro" Ltd	X-363027 Y-4686103	68.5	6.85
2	Kvirila – below "Jruchula" Ltd	X-363791 Y-4686878	66.7	6.67

Mn content in Kvirila River suspended particles and bottom sediments is high, especially near "Andro" LTD, compared to "Jruchula" LTD. At the same time, Mn content in bottom sediments is higher compared to suspended particles and comprises 68.5 and 58.3 g/kg, respectively, while manganese content in bottom sediments near "Jruchula" LTD comprises 66.7 and equals to 23.6 g/kg for suspended particles. At that it should be noted that Kvirila River water is colored black in the surroundings of these enterprises that is caused by large quantity of bottom sediments and suspended particles.

Conclusions

- pH of Kvirila River varies within a range of 7.7-8.2, and within 7.8-8.3 in spring waters;
- in Kvirila River waters, concentrations of major cations and anions in samples taken from polluted places, don't exceed MPC and are within the norm. Increased amount of sulfate ions has been registered in Kvirila River in one case only, below the enterprise. In general, Kvirila River water belongs to the category of medium-salt waters (average mineralization);
- manganese concentration equals to 2.56 mg/l, that comprises 25.6 MPCs. This is caused by the fact that below the enterprise Kvirila River is contaminated due to dump of waste waters originated resulting from extracted ore washing;
- among polluting ingredients, nitrites (3.8 MPC and 1,3 MPC in first and second spring waters, respectively) and sulfates (2.0 MPC in first spring water) are distinguished by high content in spring waters; they belong to the category of medium-salt (average mineralization) and highly mineralized waters;
- manganese content in the waters of both springs is within the norm;
- total Mn content in Kvirila River suspended solids and bottom sediments is very high compared to the background one;
- except for manganese, no one of identified heavy metals has been found in quantities more than MPC;
- no contamination according to microbiological parameters has been registered in spring waters.

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